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## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<p>(54) Title: PERFORATED RETROREFLECTIVE FILM</p> <div data-bbox="292 1144 1299 1575"> </div> <p>(57) Abstract</p> <p>A see-through retroreflective structure includes a transparent polymeric film, an array of retroreflective elements attached to the polymeric film, and an array of apertures through the retroreflective structure within the array of retroreflective elements. In one embodiment, the retroreflective structure includes a metalized reflective layer formed on the transparent prism elements and a support layer, such as a fabric, is attached to the metalized reflective layer. The method includes providing a transparent polymeric film. An array of retroreflective elements is attached to the polymeric film. The array of retroreflective elements and the transparent polymeric film are perforated through the retroreflective structure to form an array of apertures, thereby forming a retroreflective structure. The apertures are of sufficient size and spacing to provide a see-through capability. In one embodiment, a metalized reflective layer can be applied to the retroreflective elements and a support layer, such as a fabric, is attached to the metalized reflective layer.</p>		

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## PERFORATED RETROREFLECTIVE FILM

## BACKGROUND OF THE INVENTION

Retroreflective materials are employed for various safety and decorative purposes. Particularly, these materials are useful at night time when visibility is  
5 important under low light conditions. With perfect retroreflective materials, light rays are reflected essentially towards a light source in a substantially parallel path along an axis of retroreflectivity.

Many types of retroreflective material exist for various purposes. These retroreflective materials can be used as reflective tapes and patches for clothing,  
10 such as vests and belts. Also, retroreflective materials can be used on posts, barrels, traffic cone collars, highway signs, warning reflectors, etc. Retroreflective material can be comprised of arrays of randomly oriented micron diameter spheres or close packed cube-corner (prismatic) arrays.

Cube-corner or prismatic retroreflectors are described in U.S. Patent  
15 3,712,706, issued to Stamm on January 23, 1973. Generally, the prisms are made by forming a master negative die on a flat surface of a metal plate or other suitable material. To form the cube-corners, three series of parallel equidistance intersecting V-shaped grooves 60 degrees apart are inscribed in the flat plate. The die is then used to process the desired cube-corner array into a rigid flat plastic surface.

20 Further details concerning the structures and operation of cube-corner micropisms can be found in U.S. Patent 3,684,348, issued to Rowland on August 15, 1972. A method for making retroreflective sheeting is also disclosed in U.S. Patent 3,689,346, issued to Rowland on September 5, 1972. The disclosed method is for forming cube-corner micropisms in a cooperatively configured mold. The  
25 prisms are bonded to sheeting which is applied thereover to provide a composite structure in which the cube-corner formations project from one surface of the sheeting.

## SUMMARY OF THE INVENTION

The present invention is directed to a "see-through" retroreflective structure and a method for forming the same. The see-through retroreflective structure includes a transparent polymeric film, an array of retroreflective elements attached  
5 to the polymeric film, and an array of apertures through the retroreflective structure within the array of retroreflective elements. In one embodiment, the retroreflective structure includes a metalized reflective layer formed on the retroreflective elements and a support layer, such as a fabric, is attached to the metalized reflective layer. The see-through feature of the structure allows a person inside a vehicle or building  
10 to see out a window while those viewing outside can see a graphic display on the structure during the day and night.

The method includes attaching an array of retroreflective elements on a transparent polymeric film. The array of retroreflective elements and the transparent polymeric film are perforated through the retroreflective structure to form an array  
15 of apertures, thereby forming a see-through retroreflective structure. In one embodiment, a metalized reflective layer can be applied to the retroreflective elements and a support layer, such as a fabric, is attached to the metalized reflective layer.

The present invention can be used as trim on clothing apparel, such as  
20 running suits and running shoes. In particular, the invention can display a moiré pattern. Also, the invention can be used on windows to partially retroreflect incoming light while allowing a person to partially see through the window from the other side. Further, the invention can be used as advertising display panels on windows, as reflective sun screens for windows in automobiles, etc. Furthermore,  
25 the structure is suitable for ink jet and digital printing with a whiteness background.

## BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a cross-sectional view of a first embodiment of a retroreflective structure of the present invention.

Figure 2 is a top view of the first embodiment of a retroreflective structure of the present invention.

Figure 3 is a cross-sectional view of a second embodiment of the retroreflective structure of the present invention.

5        Figure 4 is a schematic diagram of a second embodiment of the method for forming the invention.

Figure 5 is a cross-sectional view of a method for forming an alternative retroreflective structure at a first point in forming a third embodiment of the present invention.

10       Figure 6 is a cross-sectional view of a method for forming an alternative retroreflective structure at a second point in forming the third embodiment of the present invention.

Figure 7 is a cross-sectional view of a method for forming an alternative retroreflective structure at a first point in forming a fourth embodiment of the  
15       present invention.

Figure 8 is a cross-sectional view of a method for forming an alternative retroreflective structure at a second point in forming the fourth embodiment of the present invention.

Figure 9 is a cross-sectional view of a method for forming an alternative  
20       retroreflective structure at a point in forming a fifth embodiment of the present invention.

Figure 10 is a cross-sectional view of a method for forming an alternative retroreflective structure at a point in forming a sixth embodiment of the present invention.

25       Figure 11 is a cross-sectional view of a method for forming an alternative retroreflective structure at a second point in forming the sixth embodiment of the present invention.

Figure 12 is a cross-sectional view of a method for forming an alternative retroreflective structure at a first point in forming a seventh embodiment of the  
30       present invention.

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Figure 13 is a cross-sectional view of a method for forming an alternative retroreflective structure at a second point in forming the seventh embodiment of the present invention.

Figure 14 is a cross-sectional view of a method for forming an alternative retroreflective structure at a third point in forming the seventh embodiment of the present invention.

Figure 15 is a cross-sectional view of a method for forming an alternative retroreflective structure at a point in forming an eighth embodiment of the present invention.

## 10 DETAILED DESCRIPTION OF THE INVENTION

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of preferred embodiments of the invention, as illustrated in the accompanying drawings in which like reference characters refer to the same parts throughout the different views. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention. All percentages and parts are by weight unless otherwise indicated.

Retroreflective structure 10, as shown in Figure 1, has a base film 12 that is comprised of a transparent thermoplastic film, such as polyvinyl chloride, polyvinylidene chloride, urethane films, polyfluorocarbon polymers, etc. In another embodiment, the thermoplastic is an ethylene-tetrafluoroethylene copolymer. Base film 12 is transparent to visible light and can be either clear or colored. An example of a suitable base film 12 is a polyvinyl chloride film available from Renoliot Corp. under the trademark Renoliot™ H1W series. Base film 12 can have a thickness in the range of between about 0.001 and 0.022 inches (0.025 and 0.56 mm). In a preferred embodiment, the thickness is in the range of between about 0.008 and 0.02 inches (0.2 and 0.51 mm). The selected thickness is dependent upon the method of fabrication, such as heating, radio high frequency welding, ultrasonic welding, the

thermoplastic selected, and the characteristics desired for the retroreflective structure.

The prism array 14, which can include retroreflective cube-corner prism elements 16, is formed on the base film 12. Prism array 14 has a window side 18  
5 exposed to incoming rays R and facet sides 20 and is attached on window side 18 to the base film 12. Prism array 14 is formed of a transparent polymer. After being formed, the polymer is preferably rigid at room temperature, which is defined as being substantially inflexible. The rigidity of the polymer in the prism array allows the prism elements to retain their optical characteristics. The prism array polymer  
10 can also be non-extensible, which is defined as not being capable of being substantially stretched without breaking. The polymer is selected from a wide variety of polymers which include the polymers of urethane, acrylic acid esters, cellulose esters, ethylenically unsaturated nitriles, hard epoxy acrylates, etc. Other polymers include polycarbonates, polyesters and polyolefins, acrylated silanes, hard  
15 polyester urethane acrylates. Other polymers which are not as rigid can also be used. These include polyvinyl chloride and polyvinylidene chloride. Preferably, the polymer is cast in a prismatic mold with a monomer or oligomer polymerization initiated by ultraviolet radiation.

The prism elements 16 of the prism array 14 can be cube-corner in shape and  
20 have a length along each cube-side edge in the range of between about 0.004 and 0.02 inches (0.1 and 0.51 mm). In one embodiment, each cube-side edge has a length of about 0.006 inches (0.15 mm). Preferably, each cube-side edge has a length of between about 0.004 and 0.008 inches (0.1 and 0.2 mm).

The thickness of prism array 14 at valley 22, where the rigid prism elements  
25 intersect, is preferably sufficiently thin so that the prism array 14 can crack and split along the valleys 22 when a minimal force is applied to retroreflective structure 10. In one embodiment, the thickness of prism array 14, which is the distance from window side 18 to apex 21 of prisms, is in the range of between about 0.002 and 0.009 inches (0.05 and 0.23 mm).



The base film 12 provides a substrate for prism array 14 to provide a smooth surface upon which the prism elements can be attached. The window side 18 of the prism elements 16 is attached to the base film 12. The prism array 14 can be laminated to the base film 12 with a transparent adhesive. Alternatively, the prism  
5 array 14 can be cast directly onto the base film 12.

An adhesive 24 can be applied to the prism facets 20 for attaching a backing layer to the retroreflective structure. If an adhesive is employed on the prism facets, the adhesive can cause the surface of the prisms to wet, thereby destroying the air interface and eliminating the ability of the prism to retroreflect. As a result,  
10 reflective coating 26 is preferably deposited on the surface of the dihedral facets 20. Typically, the reflective coatings are formed by sputtering aluminum, silver or gold or by vacuum metalization. Alternatively, metal lacquers, dielectric coatings and other specular coating materials can be employed.

Backing layer 28 is placed on the facet side 20 of the prism array 14. The  
15 backing layer 28 can be formed of a thermoplastic. For instance, backing film 28 can be formed from a thermoplastic, such as a polyvinyl chloride, polyvinylidene chloride, urethane films, polyfluorocarbon polymers including an ethylene-tetrafluoroethylene copolymer, etc., which has a low temperature of distortion. The thermoplastic of backing layer 28 can be transparent to visible light and is either  
20 clear or colored. Alternatively, backing layer 28 can be a cloth or fabric, such as a polyester cloth. In one preferred embodiment, the base film 12 and backing layer 28 both include polyvinyl chloride. Backing layer 24 can have a thickness in the range of between about 0.005 and 0.02 inches (0.12 and 0.51 mm).

In accordance with the invention, a plurality of apertures 30 are formed in  
25 retroreflective sheeting 10 and extend through the thickness of retroreflective structure 10. The apertures are of sufficient size and spacing from one another to allow the average person to see through the otherwise opaque structure. The apertures 30 can be formed, such as by punching holes in the structure using a suitable tool of various shapes including circles, ovals, rectangles, squares, etc.  
30 Also, the apertures can be in the shape of letters or a logo. Apertures 30 can be

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uniformly or randomly arranged in an array on the structure. Typically, the apertures 30 can be circles having a diameter in the range of between about 6.0 and 18 millimeters (0.25 and 0.75 inches). The array of apertures can cover about 50 percent of the surface area of the retroreflective structure. The apertures provide  
5 breathability to the structure. The retroreflective structure, when superimposed over another perforated structure, can result in a moiré effect. Such configurations can be incorporated into clothing or footwear to provide a decorative pattern while providing retroreflectivity for safety.

The base film and prism array portion of one embodiment of the  
10 retroreflective structure 10 can be formed by one of the methods disclosed in U.S. Patent 3,684,348, issued to Rowland on August 15, 1972; U.S. Patent 3,689,346, issued to Rowland on September 5, 1972; U.S. Patent 3,811,983, issued to Rowland on May 21, 1974; U.S. Patent 3,830,682, issued to Rowland on August 20, 1974; U.S. Patent 3,975,083, issued to Rowland on August 17, 1976; U.S. Patent  
15 4,332,847, issued to Rowland on June 1, 1982; U.S. Patent 4,801,193, issued to Martin on January 31, 1989; U.S. Patent 5,229,882, issued to Rowland on July 20, 1993; U.S. Patent 5,236,751, issued to Martin *et al.* on August 17, 1993; U.S. Patent 5,264,063, issued to Martin on November 23, 1992; U.S. Patent 5,376,431, issued to Rowland on December 27, 1994; U.S. Patent 5,491,586, issued to Phillips on  
20 February 13, 1996; U.S. Patent 5,512,219, issued to Rowland on April 30, 1996; U.S. Patent 5,558,740, issued to Bernard *et al.* on September 24, 1996; U.S. Patent 5,592,330, issued to Bernard on January 7, 1997; and U.S. Patent 5,637,173, issued to Martin *et al.* on June 10, 1997.

In one embodiment, a six mil (0.15 mm) polyvinyl chloride film is laminated  
25 to a two mil (0.05 mm) polyethylene terephthalate (PET) carrier. The polyvinyl chloride film is tie coated and retroreflective prisms are cast on the tie coated polyvinyl chloride film. The retroreflective prisms are metalized. The metalized layer may or may not need to be protected by a coating of some type depending on the application requirements. In embodiments where a silver appearance of  
30 metalization is not preferred, a color (either the same color as the top surface or

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another) can be printed or coated on the metalized layer. A top view of the retroreflective structure is shown in Figure 2.

Referring now to Figure 4, a preferred method of forming the invention will now be described in further detail. A metalized retroreflective structure film 100, formed as described above, is unwound from roll 102 and directed to a device 104, such as a step and repeat die punch system, for punching apertures in retroreflective structure film 100. The metalized retroreflective structure film 100 is wound up at windup station 106. The punched particles 50 of retroreflective film described in detail above and shown in Figure 3 drop onto auto platen 105 and are collected from platen 105. Alternatively, as shown in Figure 4, the particles 50 can be directly applied from device 104 to an adhesive coated substrate 110, such as a fabric, which is unwound from fabric roll 112, as shown in Figure 4. Particles 50 can also be dispersed onto the adhesive side 113 of the adhesive coated substrate 110 from particle dispenser 114. Pinch rollers 116 press the particles against adhesive coated substrate 110. Any loose particles are caught in tray 118 as the adhesive coated substrate and particles exit pinch rollers 116. Top film 122 is unrolled from top film roller 124 and is laminated to adhesive coated substrate with particles in between the two layers by laminating rollers 126. The laminated structure 127 is wound up on windup roller 128.

The particles are suitable for use as decorative or conspicuity particles on clothing, T-shirt signs, pavement marking lines, traffic signs, bicycle helmets, tarpaulins, etc. The particles can be mixed in a gel and applied to a substrate.

For use in low temperature processes (below the melting temperature of PET or polyvinyl chloride), the particles stay intact within the plastic substrate during lamination. For use where the polymer processing temperature exceeds the melting point of PET, the film deforms and melts the prisms but the reflective coating remains intact.

In another embodiment, the perforated retroreflective structure can be applied to the inside of a window. Shown in Figure 5, polyvinyl film 140 is laminated to a carrier film 142, and the polyvinyl film 140 is coated with tie coat

144. Prisms 146 are cast on the tie coat 144. The prisms are silver metalized such that the metalized portion 148 turns black. The structure is perforated with a stamping device to form aperture 150. A barrier film 152, such as paper or polypropylene, is added to the metalized side 148 with an adhesive 151 to provide  
5 dimensional stiffness and allows the film to be ink jet printed. Shown in Figure 6, the carrier film is removed and the polyvinyl film is either screen printed or ink jet printed using plasticol inks 154. By using such inks, the surface of the polyvinyl film 140 has a static cling property, thereby allowing the structure to be applied on the inside of a window 156. Screen printing is a preferred embodiment for long runs  
10 or ultraviolet light resistant applications. In another embodiment, a PET film can be used for the top layer for printing on.

The perforated retroreflective structure can be applied to the outside of a window. Shown in Figure 7, a method for forming the structure includes applying a tie coat 160 to PET film 162. Prisms 164 are cast on the tie coat 160 and then  
15 metalized to form metalized layer 166. The metalized prisms are coated with a removable acrylic-based adhesive 168, preferably with a black pigment incorporated therein, and a silicone coated paper release liner is applied to the acrylic-based adhesive. The film is perforated with a perforator to form aperture 172. A barrier film 174, such as paper or polypropylene, is attached to the release liner 170 to  
20 provide additional dimensional stiffness. The film can then be printed on the exposed PET side with screening 176, ink jet printing or another suitable method. Ink jet printers can be a pigmented solvent system that can offer ultraviolet light resistance for about twelve months. As shown in Figure 8, the temporary release liner 170 is removed and the retroreflective structure can be attached to the outside  
25 of a window 180.

In another embodiment, shown in Figure 9, a polyvinyl film can be laminated to a carrier film, such as a two mil (0.05 mm) PET film 162, and then the polyvinyl film 182 is tie coated. Retroreflective prism elements are cast on the tie coat 160 and then are metalized. The metalized prisms are coated and the carrier

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film is printed on by a similar step as discussed in the prior paragraph. The structure can be applied to the outside of a window.

A transflector material for use in airport signs is typically back lit, but it needs to be retroreflective in the event of a power outage. In one embodiment, the transflector material, shown in Figure 10, is formed by laminating a polyvinyl film 200 to a carrier film 202, such as PET, and the polyvinyl film is coated with a tie coat 206. Prisms 208 are cast on the tie coat 206. The prisms 208 are metalized with metal layer 210. The film is perforated to form apertures 212. The perforated film is laminated to a white diffuse film 214. Shown in Figure 11, the carrier film is then removed from the vinyl film. A transparent adhesive 216 is applied to the polyvinyl film, and the film is applied to a silk screen-type printed sheet 218 of polyvinyl chloride for use in a sign.

A seamless graphic film 220, as shown in Figure 12, can be formed to hide or remove seam lines created by a mold. The seam lines are removed by cutting out as much of the seam lines as possible and replacing them with glass beads 224. A polyvinyl prismatic internal reflective element film 226 with prisms 228 laminated with a PET carrier film 232 is perforated to form apertures 234. The PET carrier film 232 is removed from the perforated vinyl prismatic film 226. The perforated retroreflective prismatic film 226 is coated with a light tack removable adhesive so that the reflective surface (window surface) is in contact with the adhesive. Beads 224, preferably high refractive index glass beads, are coated on the film 220. In Figure 13, the beads 224 attach where the beads are exposed to the adhesive 236 in the apertures 234 of the vinyl prismatic film 220. The facets of the prisms 228 and the attached beads are metalized with metalized layer 230. As shown in Figure 14, base adhesive 238, preferably a white adhesive, and a backing film 240 are applied to the metalized layer 230. The low-tack adhesive 236 is removed and the film is coated with a flexible transparent weatherable ink receptive system 242. The formed structure provides a balanced set of properties with good narrow observation for long distance sight detection and with good angularity for viewing at short distances.

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In another embodiment, as shown in Figure 15, a flexible film having prisms 252 cast on a tie coat 253 and metalized layer 254 on the facets of the prisms is perforated to form apertures 256. The perforated film is laminated using an adhesive 257 to a fabric backed material 258. The film is then extrusion coated with a clear abrasion and ultraviolet light resistant material 260, such as polyvinyl chloride or polyurethane. In another embodiment, prior to lamination colored PET glitter pieces 262 are coated onto the surface of perforated film which attaches to the areas where the adhesive is present in the perforations to provide a partially glitter coated perforated reflective film.

- 10        Often white ultraviolet curable ink, either on the facets of the prisms or in the tie coat on the window side of the prisms, is used to achieve the necessary Cap Y to meet industry whiteness specifications. While the white printing enhances the Cap Y performance, it also destroys the retroreflectivity of all of the prisms it covers, thereby effectively destroying sometimes about thirty percent of the retroreflectivity.
- 15    The white printing can be in the form of a logo, lettering, etc. In addition, the step of printing can expose the prismatic film to excessive heat which can negatively impact the resulting retroreflectivity. Further, printing on the tie coat reduces the run speeds because of the difficulty in curing the prisms.

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## CLAIMS

What is claimed is:

1. A method for forming a retroreflective structure, comprising the steps of:
  - a) providing a transparent polymeric film;
  - 5 b) attaching an array of retroreflective cube-corner elements to said polymeric film; and
  - c) perforating said array of retroreflective elements and said transparent polymeric film to form an array of apertures through the retroreflective structure.
- 10 2. The method of Claim 1 wherein the array of retroreflective cube-corner elements is made retroreflective by applying a metalized reflective layer to said array of prismatic elements.
3. The method of Claim 2 wherein the metalized reflective layer is formed of a metal selected from the following group: aluminum, silver and gold.
- 15 4. The method of Claim 1 wherein a support layer is attached to the metalized reflective layer.
5. The method of Claim 4 wherein the attached support layer includes a fabric.
6. The method of Claim 1 wherein said retroreflective structure includes forming an array of apertures having between about 25 and 75 percent area  
20 of the total surface area of said retroreflective structure.
7. The method of Claim 6 wherein said apertures are formed circular in shape.

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8. The method of Claim 7 wherein said apertures are formed with a diameter in the range of between about 6.0 and 18 millimeters (0.25 and 0.75 inches).
9. The method of Claim 11 wherein said cube corner prisms are formed having a side dimension in the range of between about 0.125 and 0.51 millimeters (0.0049 and 0.02 inches).
10. The method of Claim 1 further including the step of:
  - d) collecting retroreflective particles formed by perforating the array of retroreflective elements and said transparent polymeric film.
11. The method of Claim 10 further including the step of applying said retroreflective particles to an adhesive coated substrate.
12. The method of Claim 11 further including the step of laminating a top film over the retroreflective particles to the adhesive coated substrate.
13. The method of Claim 1 wherein ink or paint is applied to the transparent polymeric film.
14. The method of Claim 13 wherein said ink includes a plasticol ink.
15. A retroreflective structure, comprising:
  - a) a transparent polymeric film;
  - b) an array of retroreflective cube-corner elements attached to said polymeric film; and
  - c) an array of apertures through the retroreflective structure within said array of retroreflective cube-corner elements.



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16. The retroreflective structure of Claim 15 wherein said retroreflective cube-corner elements include a metalized reflective layer.
17. The retroreflective structure of Claim 16 wherein said metalized reflective layer includes a metal selected from the following group: aluminum, silver  
5 and gold.
18. The retroreflective structure of Claim 16 wherein the retroreflective structure is bonded to a fabric.
19. A method for forming retroreflective particles, comprising the steps of:
  - a) providing a transparent polymeric film;
  - 10 b) attaching an array of retroreflective cube-corner elements to said polymeric film;
  - c) applying a metalized reflective layer to the retroreflective cube-corner elements;
  - d) perforating said array of retroreflective cube-corner elements and said  
15 transparent polymeric film to form an array of apertures through the retroreflective structure, thereby forming retroreflective particles; and
  - e) collecting said retroreflective particles.
20. The method of Claim 19 wherein the collected retroreflective particles are applied to an adhesive coated substrate.
- 20 21. The method of Claim 19 further includes attaching said retroreflective structure to a window.

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22. A retroreflective particle comprising:
- a) a transparent polymeric layer;
  - b) a plurality of retroreflective cube-corner elements attached to said polymeric layer; and
  - 5 c) a metalized reflective layer formed on said retroreflective elements.
23. The retroreflective particle of Claim 22 which is circular in shape and has a diameter of between about six and eighteen millimeters.

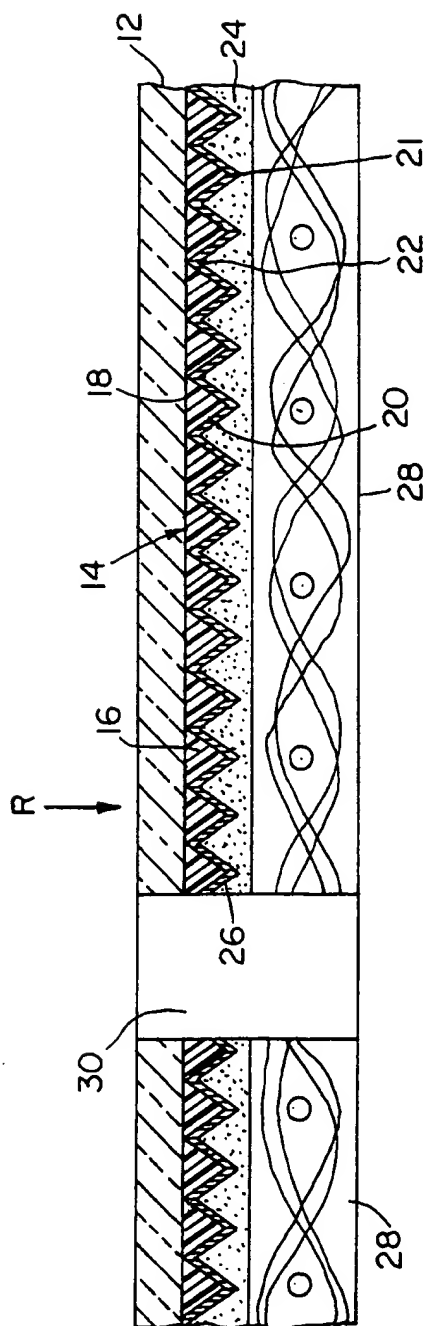


FIG. 1

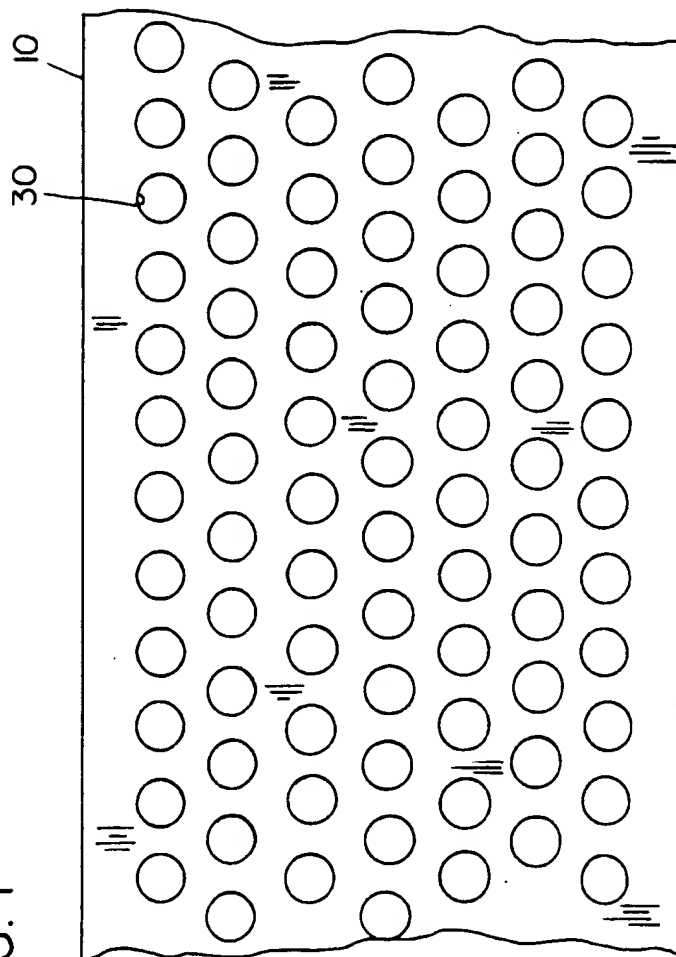
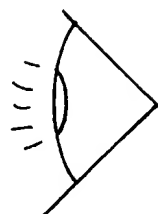


FIG. 2

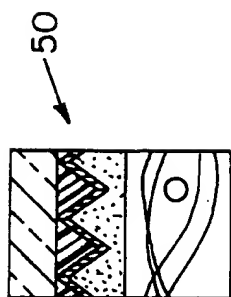


FIG. 3

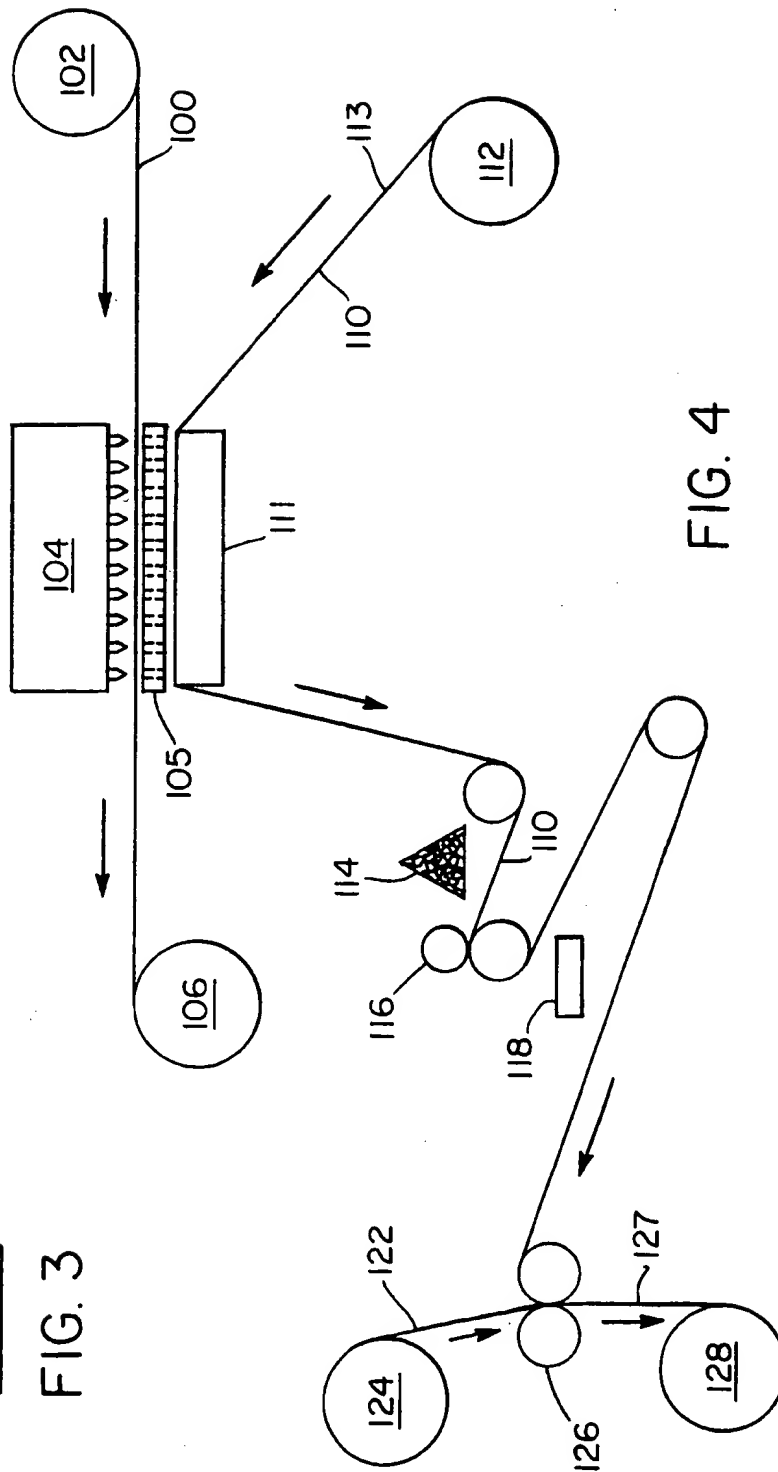


FIG. 4

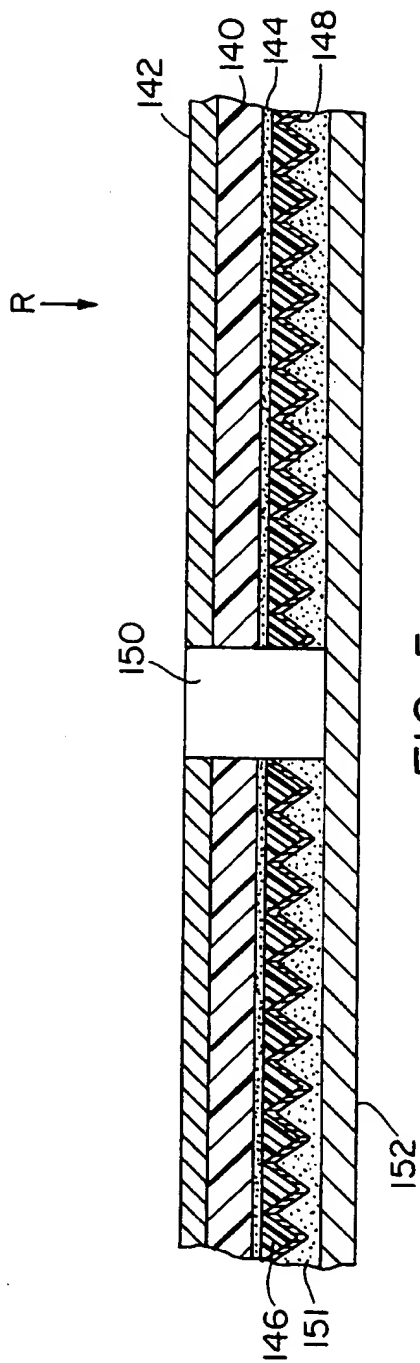


FIG. 5

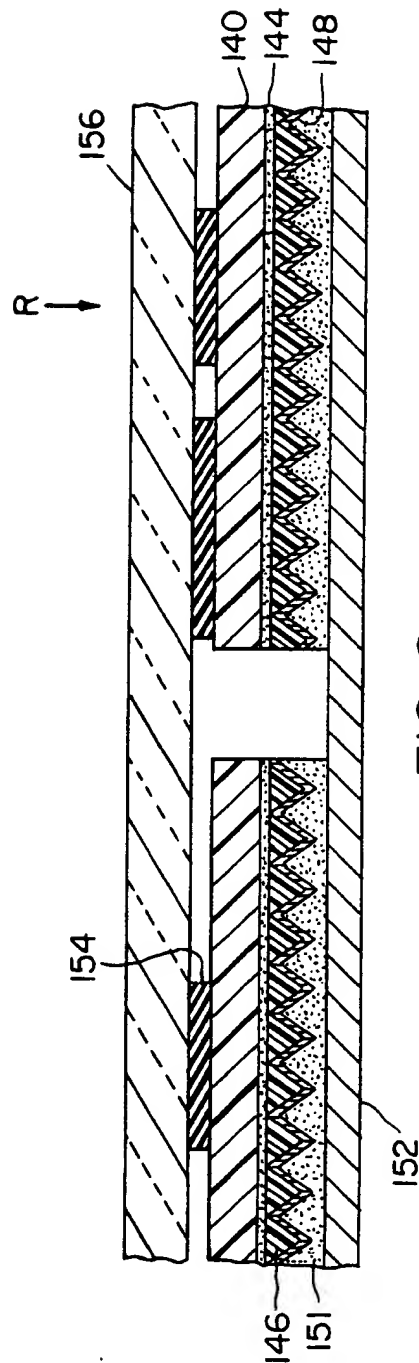


FIG. 6

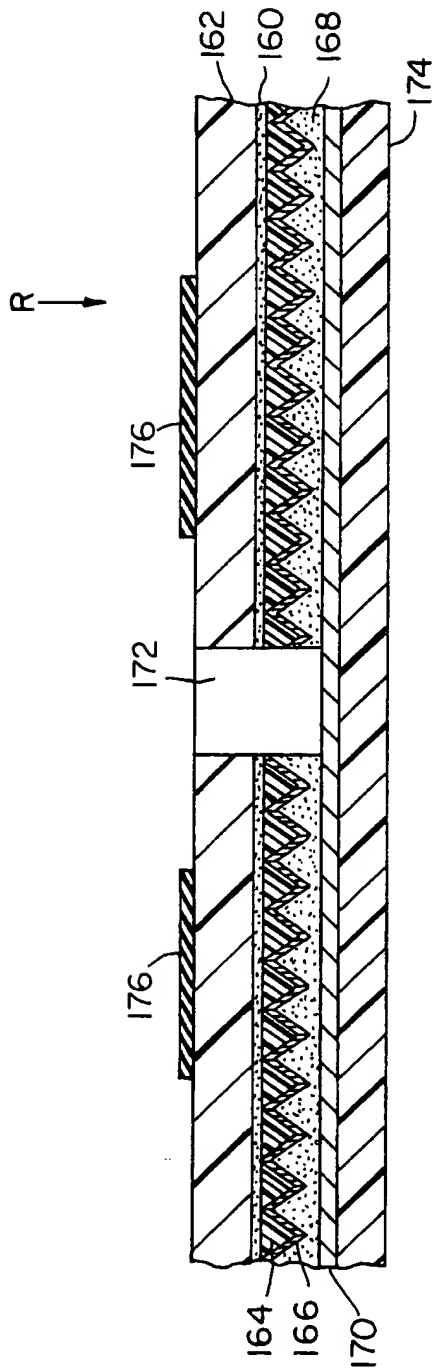


FIG. 7

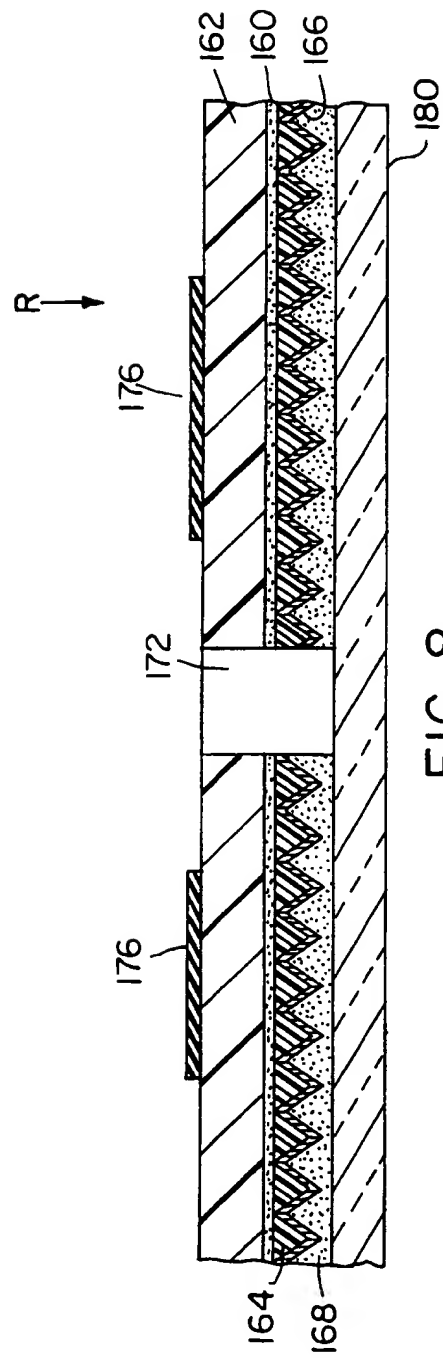


FIG. 8

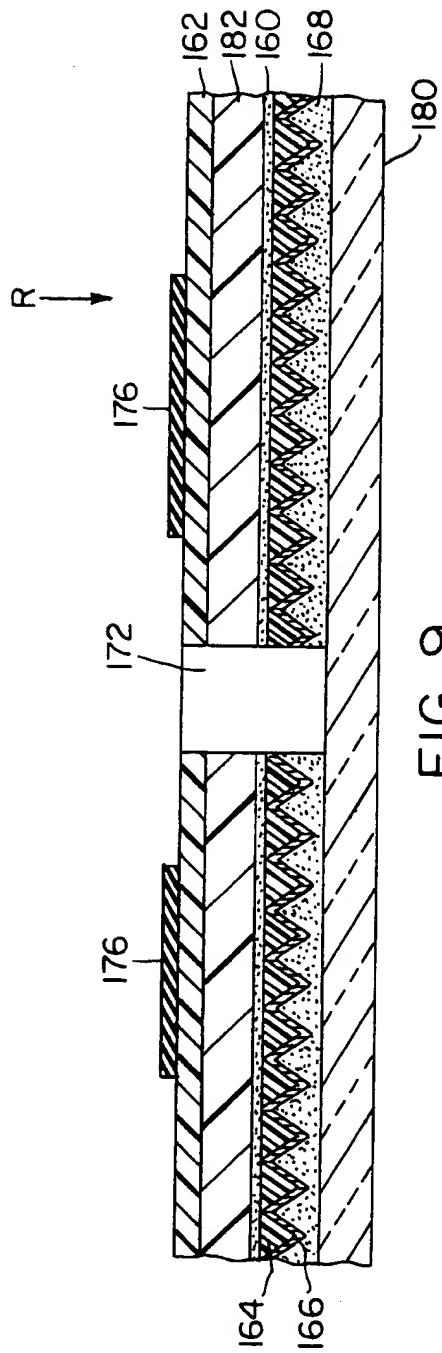


FIG. 9

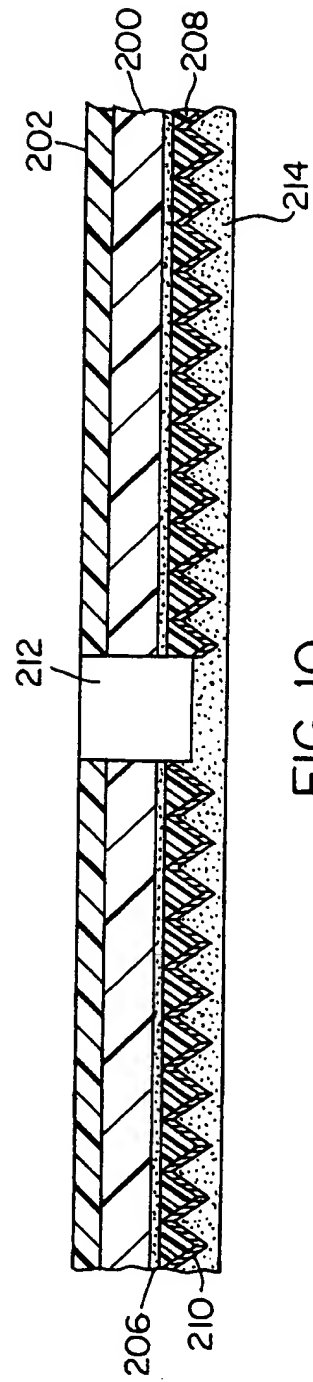


FIG. 10

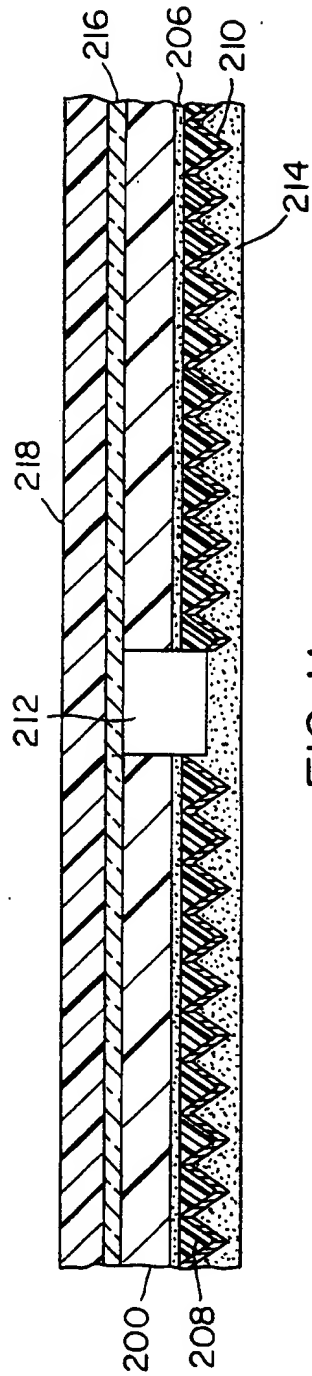


FIG. 11

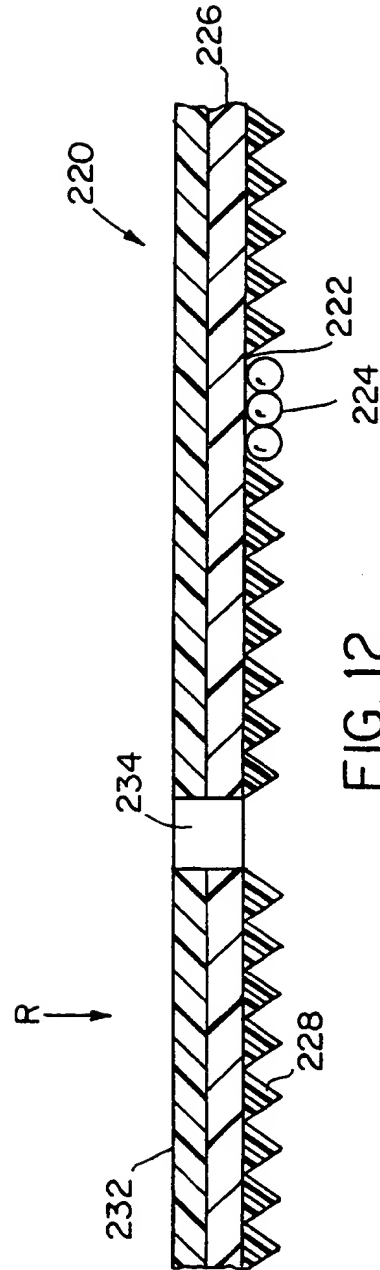


FIG. 12



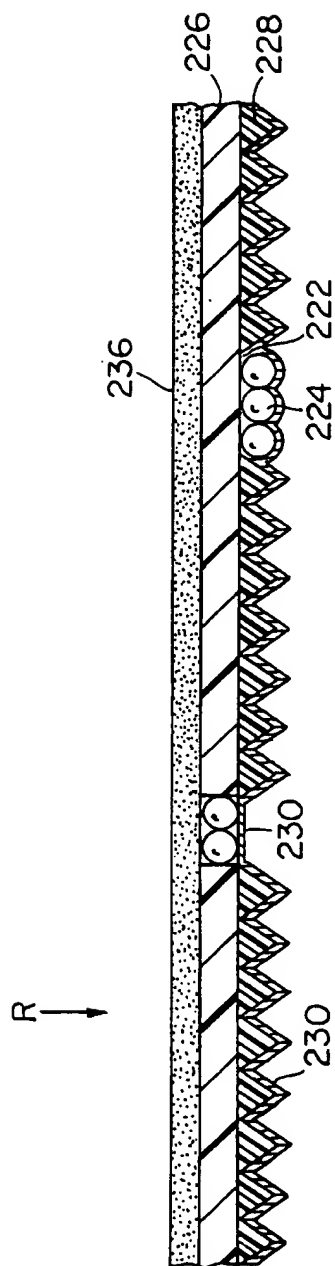


FIG. 13

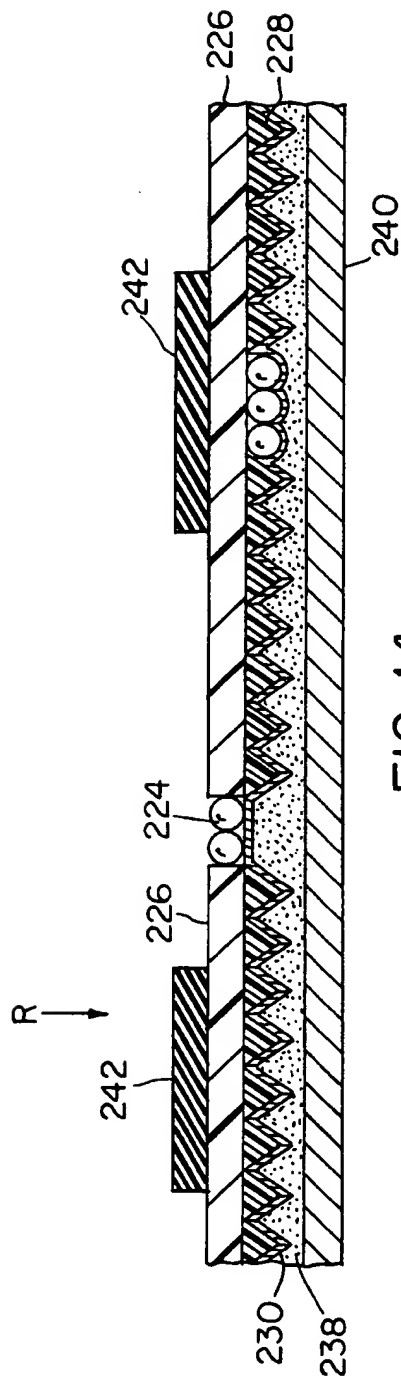


FIG. 14

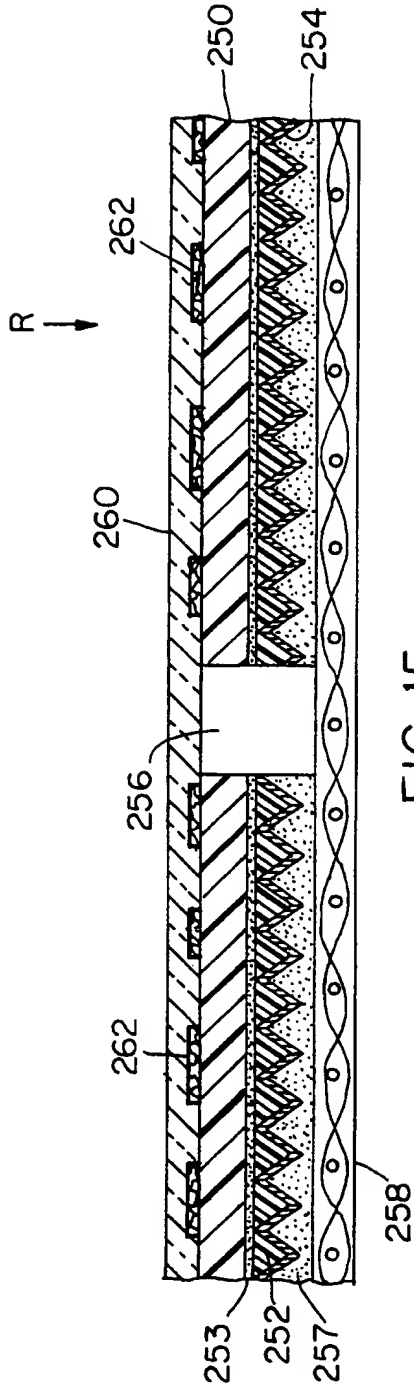


FIG. 15

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 98/26589

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 6 G02B5/124

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	US 5 679 435 A (ANDRIASH MICHAEL D) 21 October 1997  see column 5, line 24 - column 6, line 62; figures 1-6 ---	1-8, 15-18 10-14, 19-21
X A	US 4 712 868 A (TUNG CHI F ET AL) 15 December 1987  see column 1, line 65 - column 4, line 32; figures 1-3,7 --- -/--	1-5, 15-18 8,9, 19-21

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

14 April 1999

Date of mailing of the international search report

23/04/1999

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# INTERNATIONAL SEARCH REPORT

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PCT/US 98/26589

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 637 173 A (MARTIN DAVID C ET AL) 10 June 1997 cited in the application see column 2, line 3 - line 67; figures 1-5 ---	1-23
A	US 4 103 060 A (BINGHAM WALLACE KARL ET AL) 25 July 1978  see column 5, line 18 - line 68 see column 7, line 49 - column 8, line 25; figures 3,4 ---	1,10-12, 19,20, 22,23
A	US 5 614 286 A (BENSON GERALD M ET AL) 25 March 1997 see column 9, line 6 - column 10, line 47 see column 12, line 52 - column 13, line 12; figures 5-7,11 ---	1-9, 15-21
A	US 5 642 222 A (PHILLIPS EDWARD D) 24 June 1997 see column 3, line 11 - column 5, line 27; figures 1-3 -----	1-5,9, 15-19,22

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Inter. Appl. No.

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